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Agenda

- Introduction
- Technical items
  - A presentation of the practical considerations when operating both TDD and FDD systems within one band
  - A presentation of the characteristics of mid-band FWA that could apply to liberalized MVDDS (12GHz) spectrum
- Procedural items
  - Auction proceedings for 24GHz, 28GHz, 37GHz, 39GHz, 42GHz bands
  - Participation on advisory committees and other knowledge-sharing exercises

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About CBNL

- Market leader in point-to-multipoint microwave and millimeter wave
- Licensed band, FDD technology at 10.5GHz, 24.5 — 40GHz* plus unlicensed, TDD 5+60GHz Edge product
- > 150,000 units deployed in 50+ countries
- 25 pre-5G fixed wireless networks in US
- Up to 14.4Gbps per hub, up to 1.2Gbps to a site
- Up to 63 sites per sector, 15 services per site: 10,000+ customers per hub

* and formerly 3.5GHz

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Next generation thinking

A presentation of the practical considerations when operating both TDD and FDD systems within one band

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What is duplexing for?

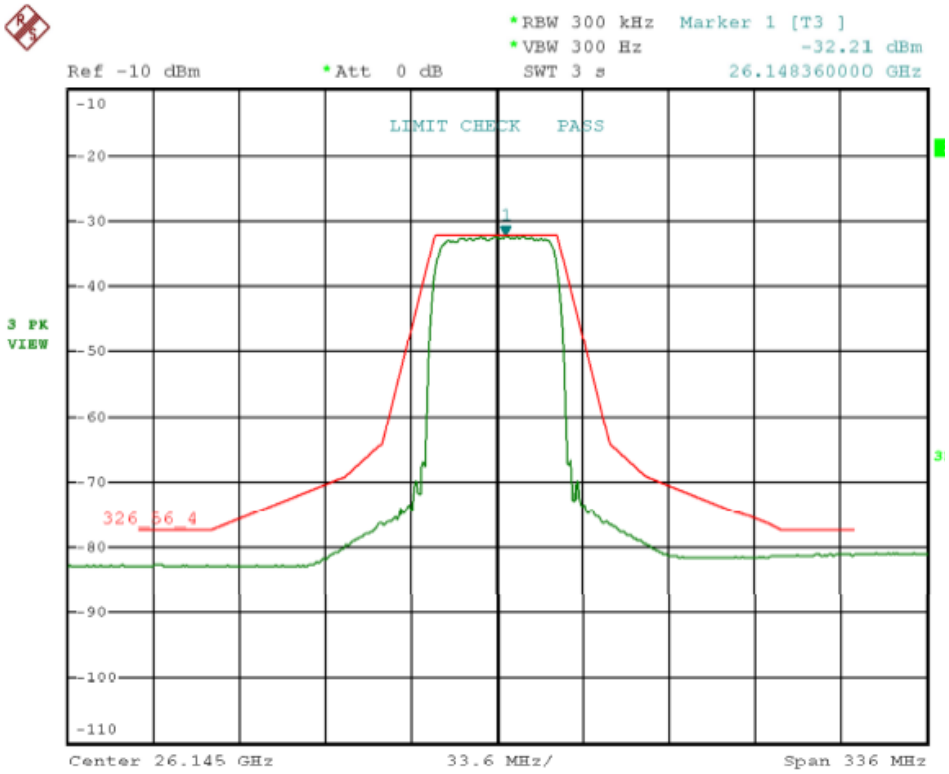
Duplexing at an individual transceiver prevents its transmitted signal from interfering with the wanted receive signal, either:

FDD …by separating TX and RX in frequency.
TDD …by separating TX and RX in time.

Often overlooked is the role of duplexing in interference avoidance amongst *groups* of transceivers using adjacent channels. Usually many transceivers are mounted on one structure (towers etc.)

Adjacent channels and interference

Practical filters are not “brick wall”, so some RF energy spreads (is allowed to spread) into the adjacent channel. How much is allowed is defined by the relevant mask (red line).



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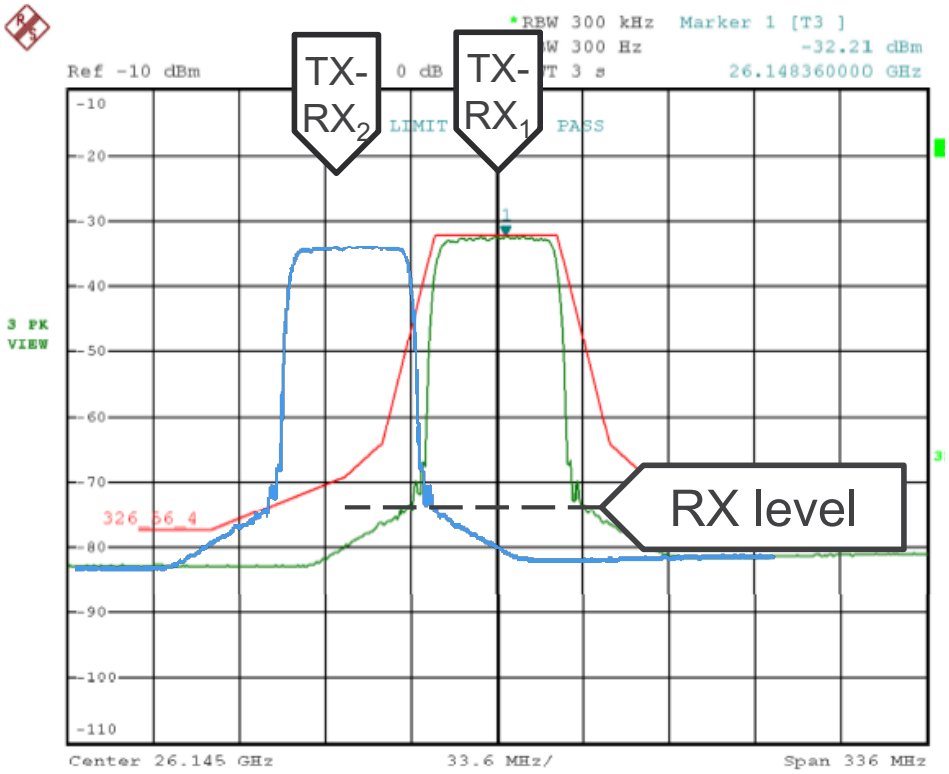
Adjacent channels and interference – TDD

Suppose we have two TDD transceivers, on adjacent channels, at the same point.

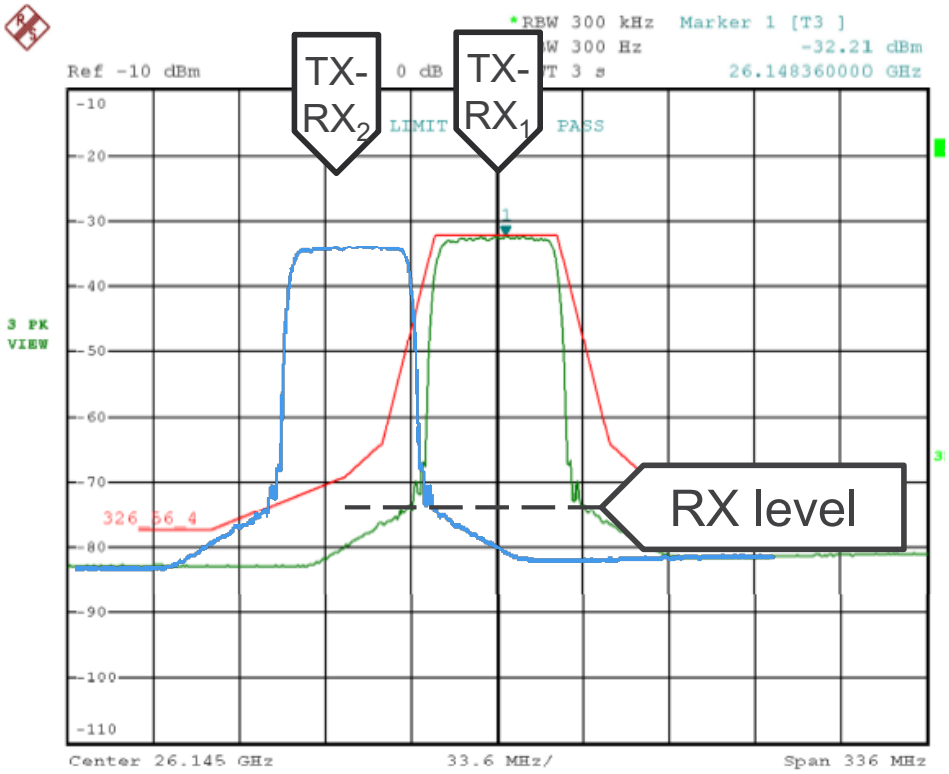
Some RF energy from the blue transmitter leaks into the adjacent channel, where the green transmitter is based.



If this occurs during the part of time when ‘green’ is attempting to receive a distant signal near the noise floor, it appears as interference.

Adjacent channels and interference – TDD (2)

To avoid interference in the TDD case, we synchronize[1] the TX-RX cycles of the two transceivers so they always both transmit or both receive at any given time.

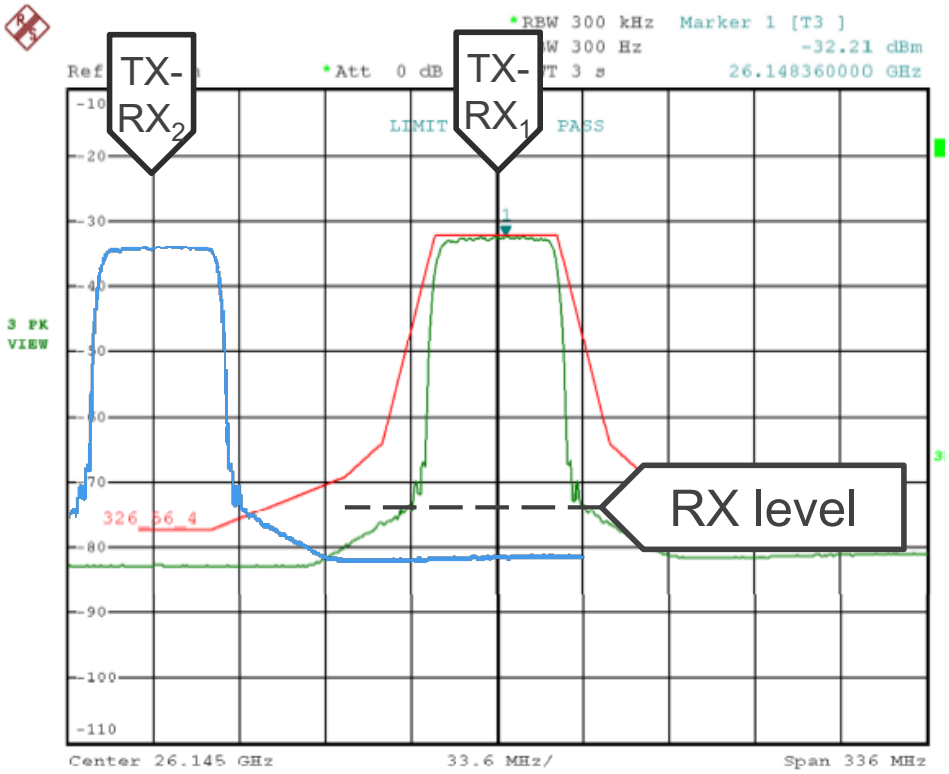


This adds complexity, and may not even be possible if the channels are in use by incompatible systems. Even if it is possible, it wastes capacity and prevents arbitrary TX-RX scheduling. Usually a fixed ratio and master network are chosen (e.g. LTE-TDD).

[1] accurately!

Adjacent channels and interference – TDD (3)

An alternative is simply to avoid using adjacent channels, or in other words, introduce a “guard band” between users.



This is effective, but wasteful of spectrum.

Additionally, it requires users to coordinate. This is not always possible.

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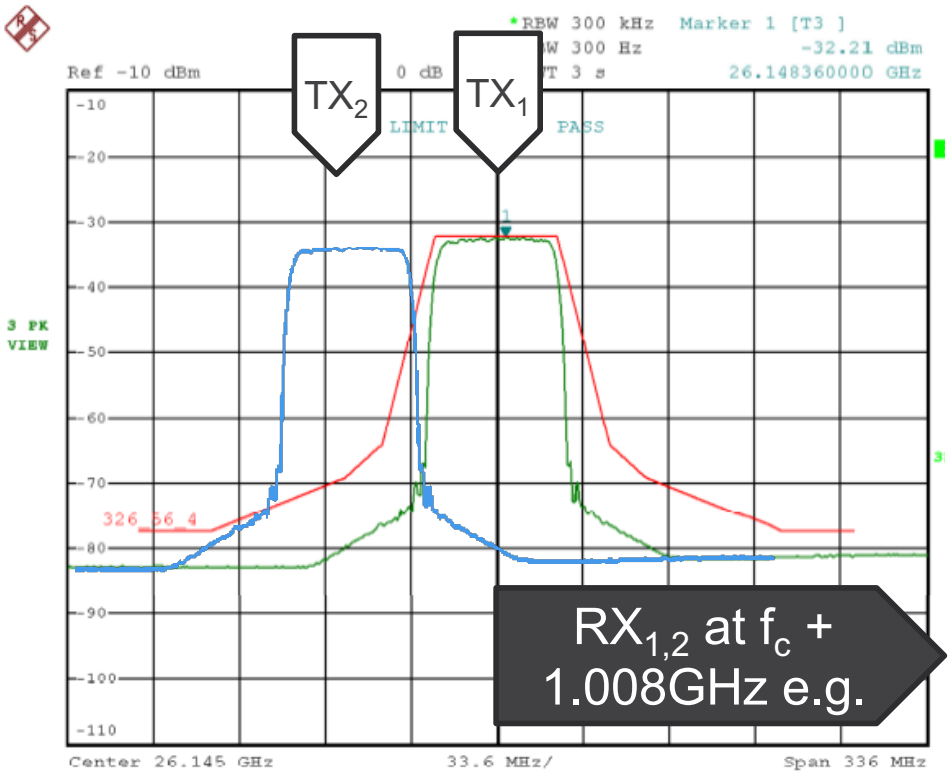
Adjacent channels and interference – FDD

Now consider two FDD transceivers, on adjacent channels, at the same point.

As long as they agree on which part of the pair to transmit in, the leaked energy does not cause interference.



This is because the receive carrier frequencies are sufficiently distant in frequency that there is no remaining leakage from the adjacent co-located transmit channel.

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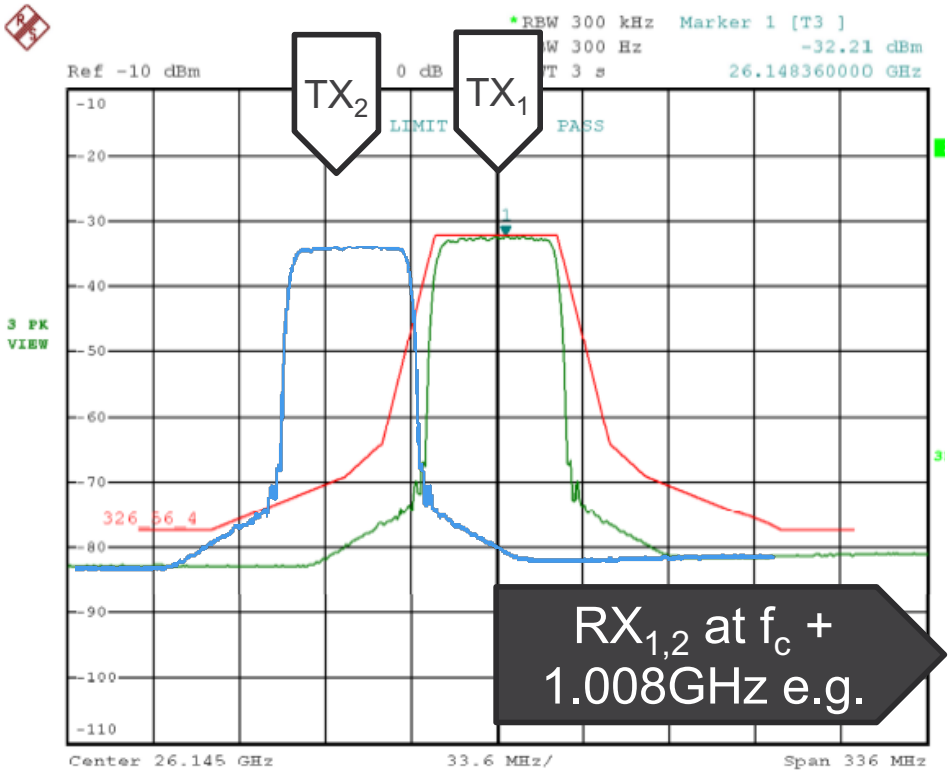
Adjacent channels and interference – FDD (2)

The interference avoidance in FDD works regardless of whether the two systems are compatible or not.



It requires no accurate synchronization, and does not require potentially competing organizations to agree on a fixed TX-RX ratio and on who is the master network. In fact users do not even need to be aware of adjacent channel systems at all.

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When are FDD and TDD commonly used?

Factor	Favours FDD	Favours TDD
Grade of service	High, SLA-backed	Best effort
Cost sensitivity	Less cost sensitive	More cost sensitive
Spectrum	Licensed	Unlicensed
Downlink – uplink ratio	Symmetric	Downlink biased
Coverage	Wide area	Local area Indoor
Applications	Mobile backhaul Enterprise access Residential access Classical fixed service	Small enterprise access Residential access

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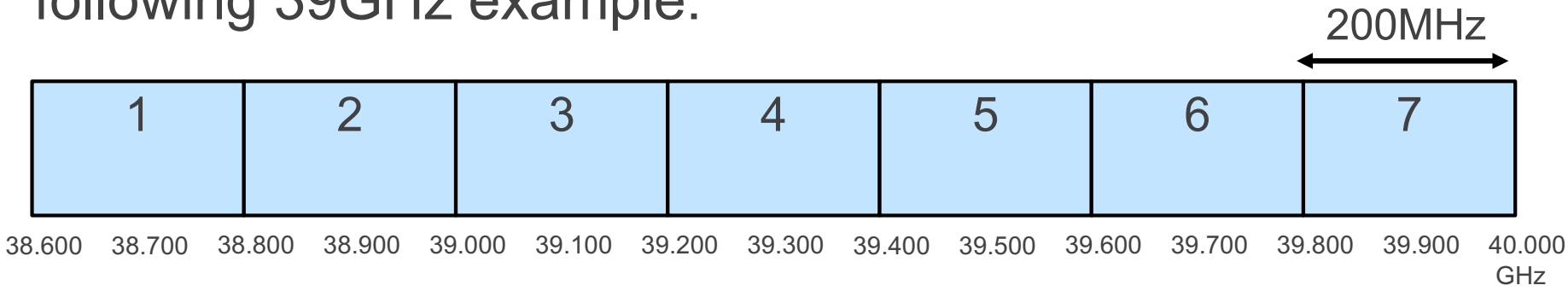
Mixing TDD and FDD: Band plans and allocation size

Superficially it seems that we can accommodate both TDD and FDD ('flexible duplexing') with a band plan such as the following 39GHz example:



The concept is that, to operate a TDD system, one is allocated a single block. To operate an FDD system, one is allocated two blocks with some separation between the two.

One problem is, then, that the minimum spectrum quantum for an FDD operator is 400MHz versus 200MHz for a TDD operator. This seems to unfairly privilege TDD operations.

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Mixing TDD and FDD: Band plans and allocation size (2)

We request that, when flexible duplexing rules are applied to bands, the minimum spectrum quantum for FDD and for TDD operations should be equal.

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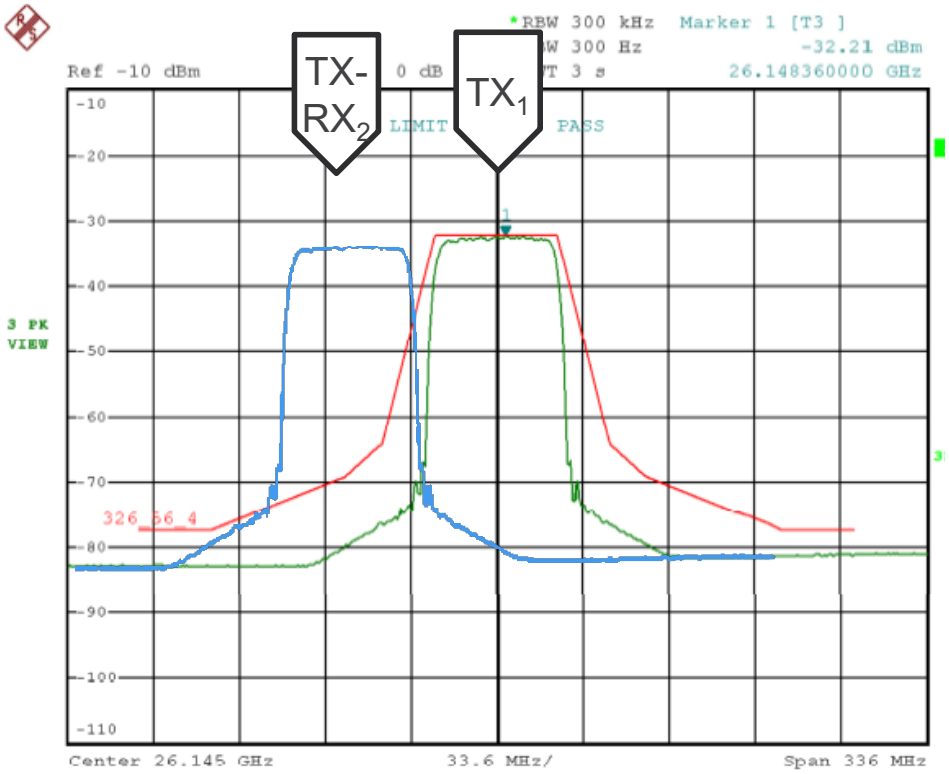
Mixing TDD and FDD: Operational considerations

If both TDD and FDD are allowed in a band, we must avoid operating them in adjacent channels. There are two cases.



Case 1: TDD system (2) adjacent to the transmit frequency of FDD system (1).

The TDD receiver suffers interference from the FDD transmitter.

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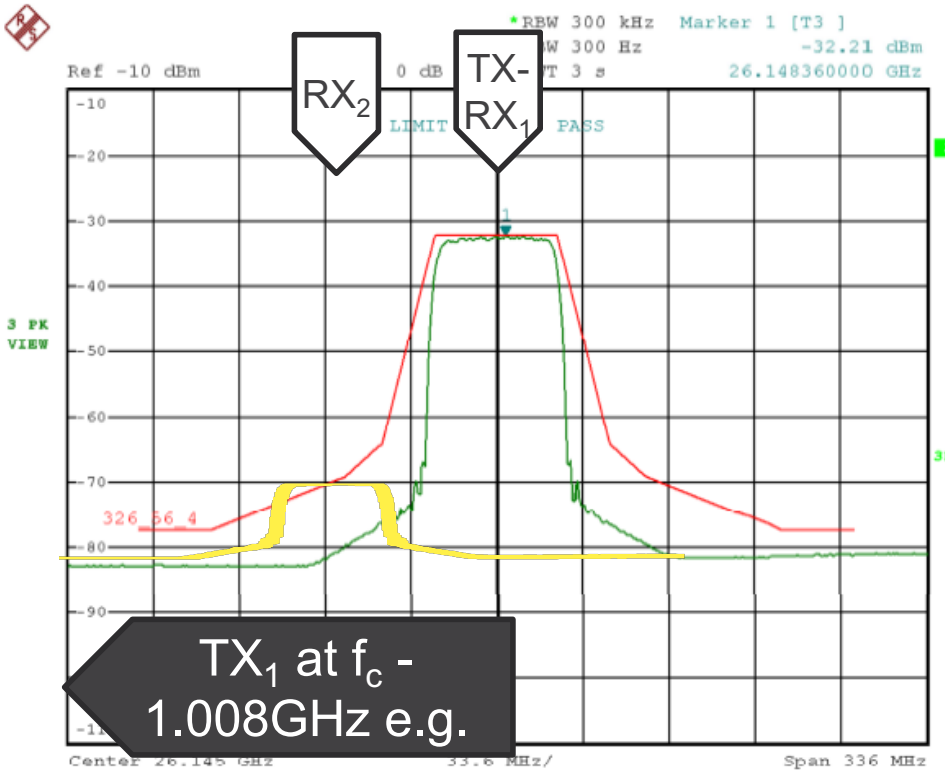
Mixing TDD and FDD: Operational considerations (2)

If both TDD and FDD are allowed in a band, we must avoid operating them in adjacent channels. There are two cases.



Case 2: TDD system (1) adjacent to the receive frequency of FDD system (2).

The FDD receiver suffers interference from the TDD transmitter.

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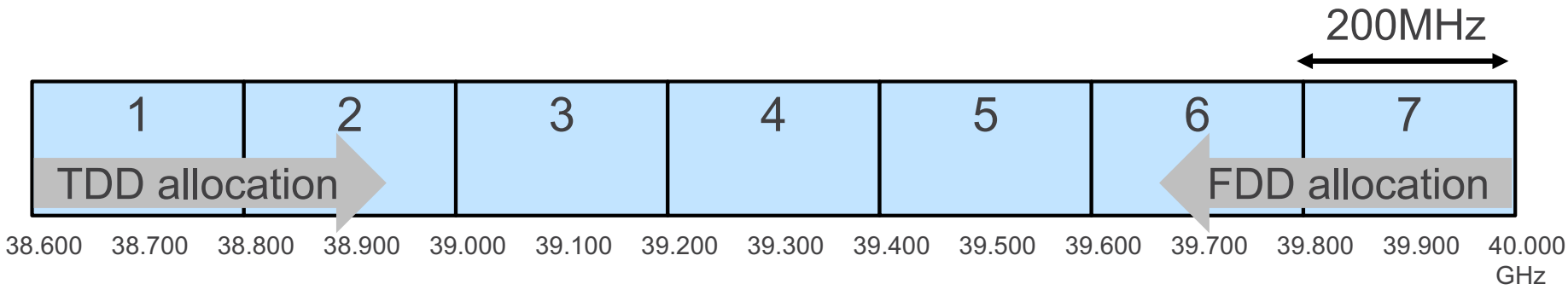
Mixing TDD and FDD: Operational considerations (3)

We can minimize the likelihood of TDD and FDD operation in adjacent channels by allocating TDD upwards from the bottom of the band and FDD downwards from the top (or vice versa).



This technique is recommended for millimeter-wave bands by the ITU-R, for example[1].

[1] RECOMMENDATION ITU-R F.2005 *Radio-frequency channel and block arrangements for fixed wireless systems operating in the 42 GHz (40.5 to 43.5 GHz) band,* March 2012.

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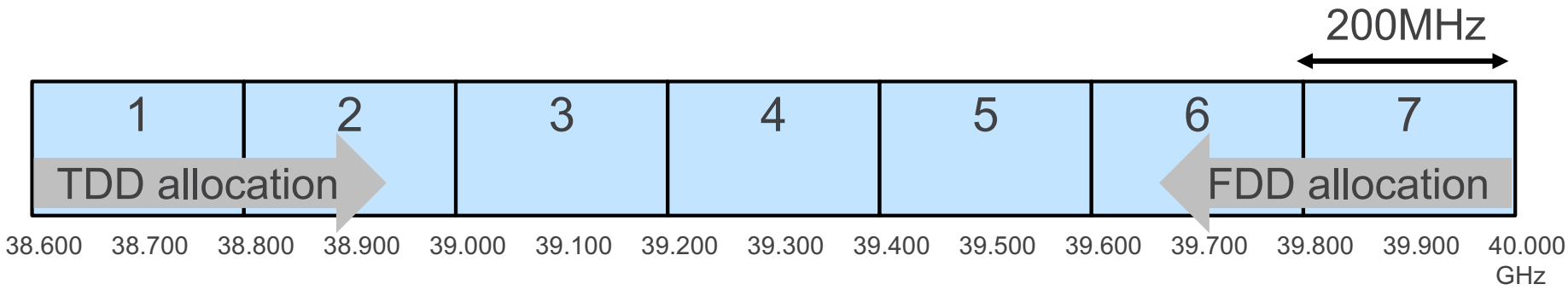
Mixing TDD and FDD: Operational considerations (4)

We can minimize the likelihood of TDD and FDD operation in adjacent channels by allocating TDD upwards from the bottom of the band and FDD downwards from the top (or vice versa).



Note — this effectively creates dynamically-sized TDD and FDD sub-bands, restoring the status quo of homogeneously duplexed contiguous spectrum.

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Next generation thinking

A presentation of the characteristics of mid-band FWA that could apply to liberalized MVDDS (12GHz) spectrum

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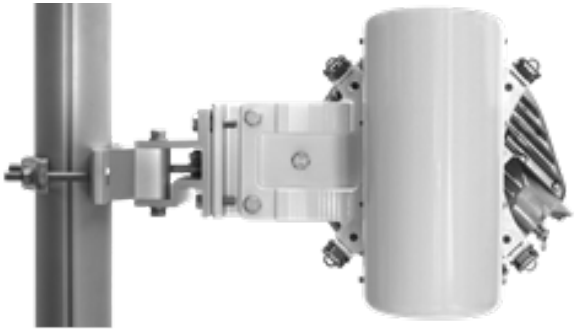
CBNL standard 10.5GHz FWA product

- 23dBm output power
- Antenna gain 18dBi (AP) 29dBi (RT)
- 99.99% availability range 10 miles[1]
- 300Mbps Ethernet throughput (28MHz paired, 256QAM)
- Many 10,000s deployed worldwide
- Usual applications: enterprise access, 3G backhaul, residential access
- Very strong business case: up to 3780 end users can be served in coverage area of 300+ square miles per base station

[1] 43mm/hr rainfall, average fading, 2' RT antenna, 28MHz channel



Access Point (AP) with 90° antenna

Remote Terminal (RT) with 1' antenna

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The 12.2—12.7GHz band

- 500MHz of spectrum allocated to Direct Broadcast Satellite (DBS), Multichannel Video Distribution and Data Service (MVDDS) and Non-Geostationary Satellite Orbit Fixed Satellite Service (NGSO FSS).

- Wider band than ITU-R F.1568 (which totals only 300MHZ) ⇒ wider channels such as 100MHz possible.

- This spectrum could allow for cost effective FWA offering Gbps+ end-user services over wide coverage areas.

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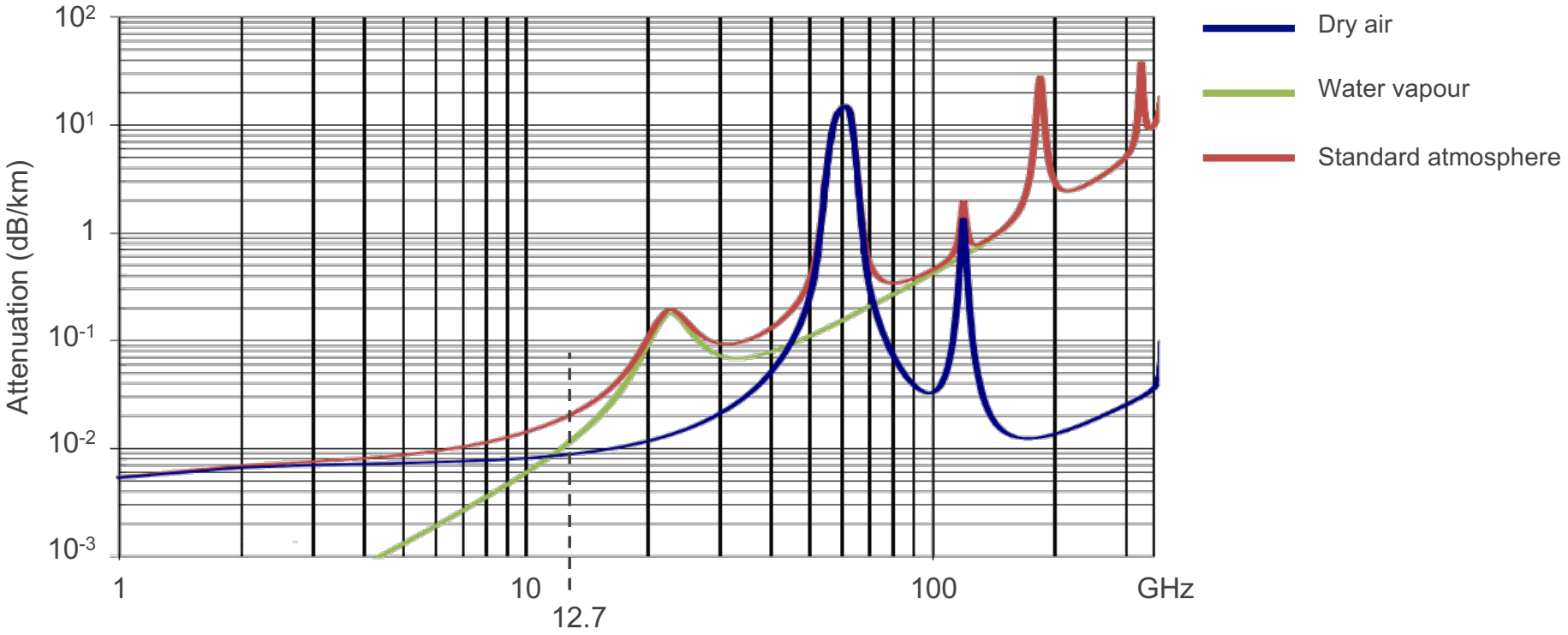
Propagation characteristics



Unsurprisingly the propagation characteristics at 12.2—12.7GHz are almost identical to those at 10.5GHz (less than 0.01dB/km difference). System range will be very similar, other factors being equal.

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12.2—12.7GHz band technical rules for MVDDS

- 14dBm/24MHz EIRP limit
- Downstream transmissions only

These rules, intended to eliminate the possibility of harmful interference to the DBS and NGSO FSS services, limit the coverage area of a high-throughput system, and complicate the deployment of a network by requiring alternate spectrum to be used for the upstream data path.

We request that the co-existence of DBS, NGSO FSS and bidirectional fixed service in 12.2—12.7GHz is revisited.